Concrete Pavement:

Rehabilitation Applications, Options & Performance

Purdue Road School

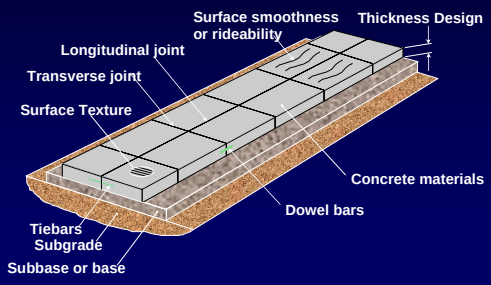
March 10, 2004

IRMCA INDIANA READY MIXED CONCRETE ASSOCIATION

INDIANA CHAPTER ACPA

Concrete Pavement Basics

Basic Components of a Concrete Pavement



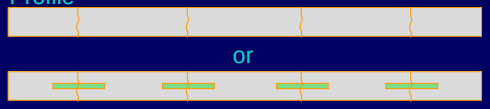
Concrete Pavement Types

- Jointed Plain
  - Undoweled
  - Doweled
- Jointed Reinforced
- Continuously Reinforced

Jointed Plain

Plan

Profile



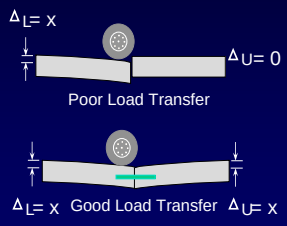
Jointed Plain

Jointed Plain

Jointed Plain

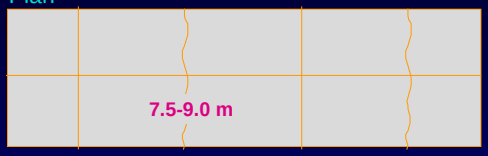
Load Transfer

- The slabs ability to share its load with its neighboring slab
  - Dowels
    - High Traffic Volumes
    - (Pavements > 8 in.)
  - Aggregate Interlock
    - Low Traffic Volumes
    - (Pavements < 7 in.)



Jointed Reinforced

Plan

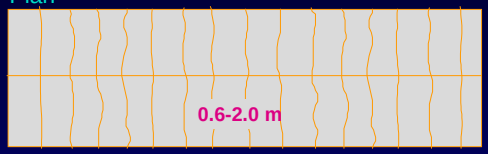


Profile

Jointed Reinforced

Continuously Reinforced

Plan

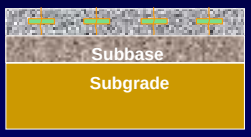


Profile

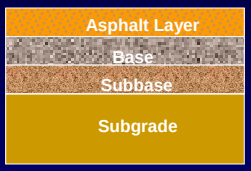
Continuously Reinforced

Different Pavement Types

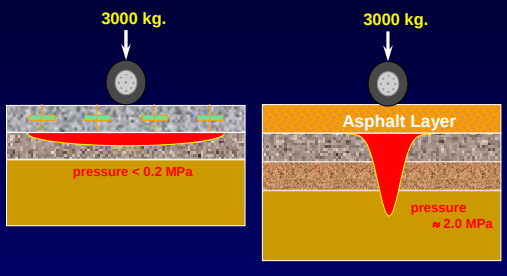
Concrete Section



Asphalt Section

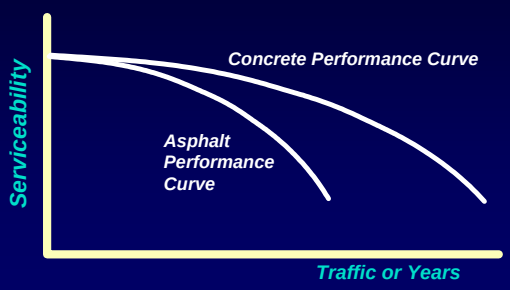


How Pavements Carry Loads

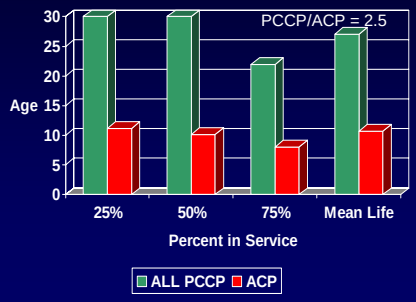


Concrete's Rigidness spreads the load over a large area and keeps pressures on the subgrade low.

Pavement Performance

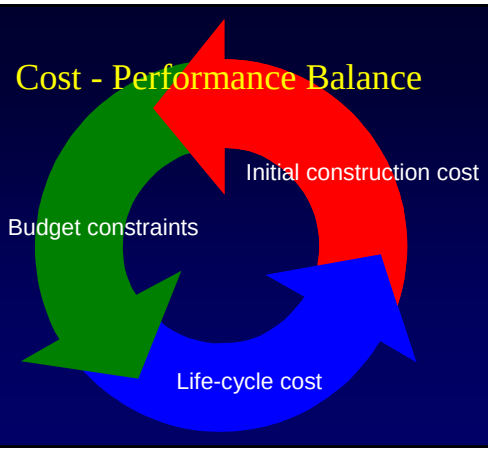


I-40 in Oklahoma Survival Analysis Results

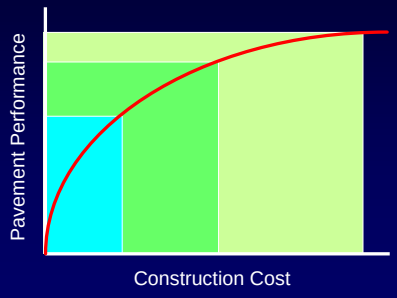


Note: Over 50% of PCCP Sections Have Not Failed (>30 Years)

Cost - Performance Balance



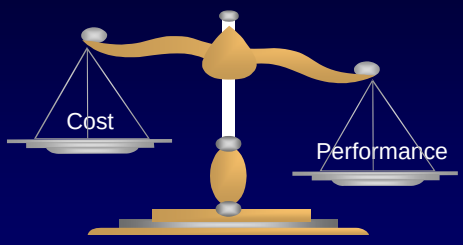
Law of Diminishing Returns



Concrete Pavement Design Requires Selecting Appropriate Features

- ☑ Subgrade modification
- ☐ Drainage system
- ☑ Subbase
- ☑ Joint Spacing
  - ☐ 6.1 m
  - ☑ 4.3 m
- ☑ Dowels
- ☑ Thickness
  - ☐ 200 mm
  - ☐ 250 mm
  - ☑ 300 mm
- ☐ Reinforcement
- ☑ Joint Sealant
  - ☐ None
  - ☐ Hot pour
  - ☑ Silicone
  - ☐ Preformed
- ☑ Surface Texture
  - ☐ Transverse tine
  - ☑ Burlap drag
- ☑ Shoulder
  - ☑ Asphalt
  - ☐ Concrete

Optimize



Concrete Pavement Rehabilitation

Rehabilitating Concrete Pavements using CPR[3]

Restoration
Resurfacing
Reconstruction

Rehabilitation Strategies

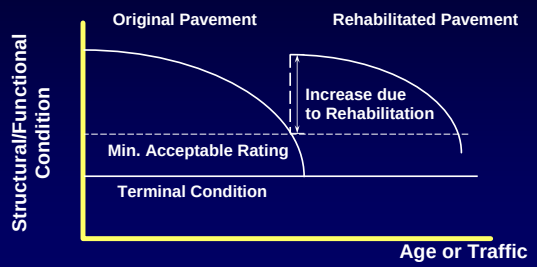
- Three categories:
  - Restoration
  - Resurfacing
  - Reconstruction

    Together, known as CPR[3]
- Which is used depends on existing condition.

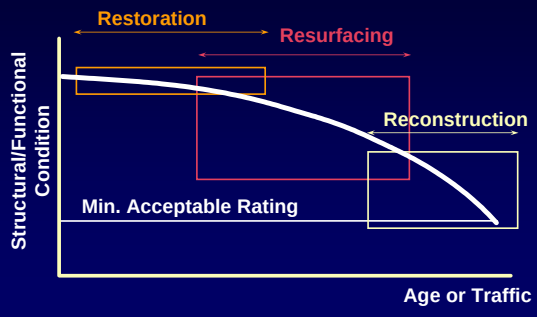
Concrete Pavement Rehabilitation

- Improves structural and/or functional condition of pavement.
  - Structural condition - the ability to carry traffic.
  - Functional condition - the ability to serve the user comfortably.

Pavement Condition

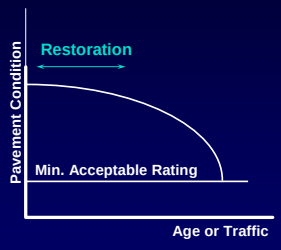


Rehabilitation Timing



Restoration (CPR)

- Used early when pavement has little deterioration.
- Repairs isolated areas of distress.



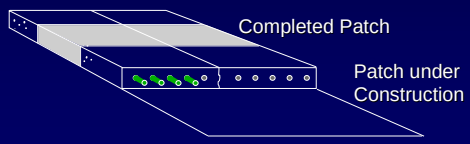
Restoration Techniques

Concrete Pavements

- Full-depth repair
- Partial-depth repair
- Diamond grinding
- Joint & crack resealing
- Slab stabilization
- Retrofitting dowels
- Retrofitting concrete shoulders
- Cross-stitching long. cracks/joints

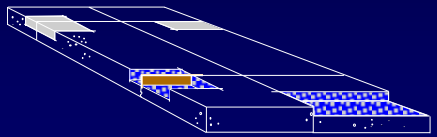
Full Depth Repairs

- Repairs distresses greater than 1/3 the slab depth.
- Consists of removing and replacing at least a portion of the existing slab to the bottom of the concrete.



Partial Depth Repairs

- Repairs deterioration in the top 1/3 of the slab.
- Generally located at joints, but can be placed anywhere surface defects occur.



Carbide-Milling

Longitudinal Milling

Transverse Milling (Half-moon)

TYPICAL SPALLS

REMOVAL

- Milling machine

MILLING IN PROGRESS

TYPICAL MILLED AREA

PDR IN PROGRESS

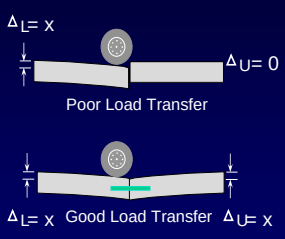
PDR IN PROGRESS

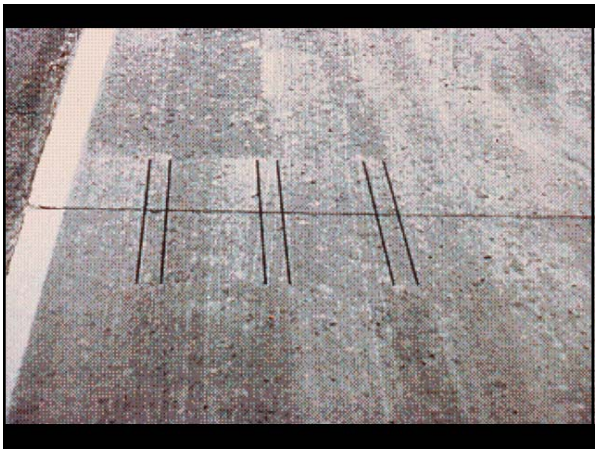
CURING

- **Use curing compound**

Load Transfer Restoration

- Reestablishes load-transfer at undoweled joints or cracks
- Used to limit future faulting



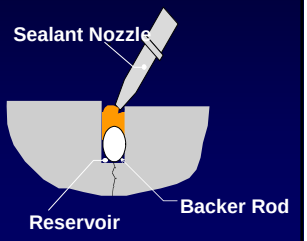


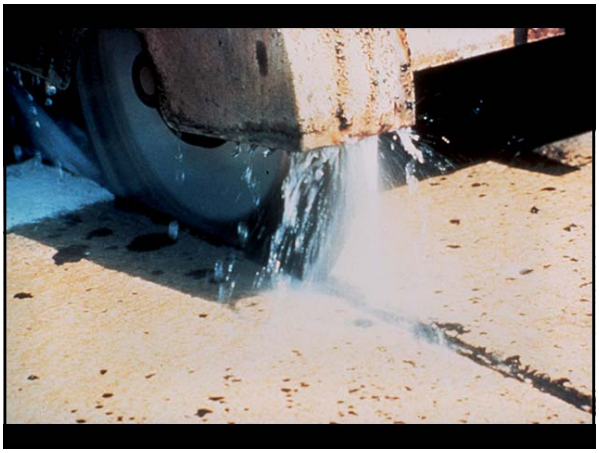
Diamond Grinding

- Improves ride by removing:
  - Faulting at joints
  - Slab warping
  - Surface deformations caused by studded tires
- Reestablishes skid resistance
- Corrects cross-slope

Joint and Crack Resealing

- Minimizes water & incompressibles into pavement system.
  - Reduces:
    - Subgrade softening
    - Pumping
    - Erosion of fines
    - Spalling





Restoration Cost Comparisons

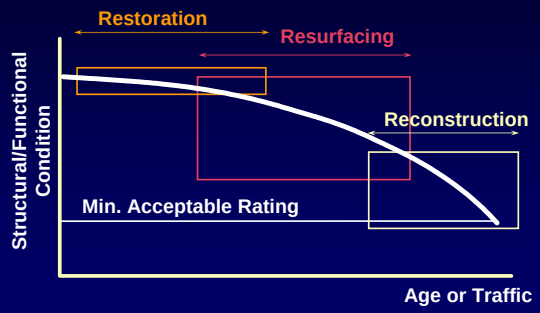
CPR in NC and dowel bar retrofit followed by diamond grinding

Location	Rehabilitation Technique	Project Size	Cost/Lane km
NC I-26	CPR	11.3 km	$ 77,640
NC I-26	Crack/Seat and AC Overlay	4.2 km	$232,920
WA I-90	DBR	53.1 km	$ 73,800
WA I-90	110 mm AC Overlay	53.1 km	$118,300

Restoration Performance

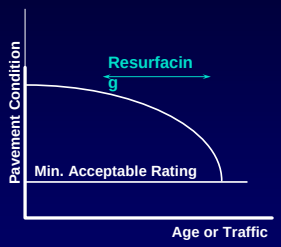
- Provides 10 or more years of service.
- Preliminary engineering & timing are critical.
- Overall effectiveness is highly dependent on design adequacy, construction quality, and other restoration activities.

Rehabilitation Timing



Resurfacing

- Used when pavement has medium to high levels of distress.
- Used when restoration is no longer effective.

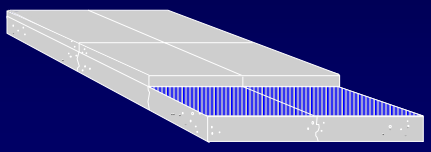


Resurfacing Activities

- Concrete overlays for concrete pavements:
  - Bonded Concrete Overlays
  - Unbonded Concrete Overlays
- Concrete overlays for asphalt pavements:
  - Conventional Whitetopping
  - Ultra-Thin Whitetopping

Bonded Overlays

- Consists of a thin concrete layer (100 mm or less) on top of an existing concrete surface.
- Specific steps are taken to bond the new concrete overlay to the existing concrete.



Bonded Overlays

Bonded Overlay

- The major use of Bonded Overlays is structural enhancement of the pavement.
- Cracks in the underlying pavement will reflect into the resurfacing
- Most often used where the underlying pavement is in reasonably good condition.

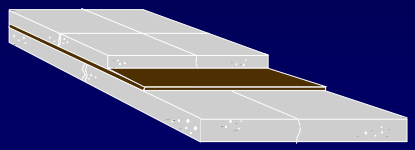
Bonded Overlays

Performance

- Good when:
  - Placed correctly and at the right time.
- Poor when:
  - Placed on deteriorated pavements.
- Loss of bond does not necessarily constitute failure.

Unbonded Overlay

- Consists of thick concrete layer (125 mm or greater) on top of an existing concrete.
- Uses a “separation interlayer” to separate new overlay and existing concrete.



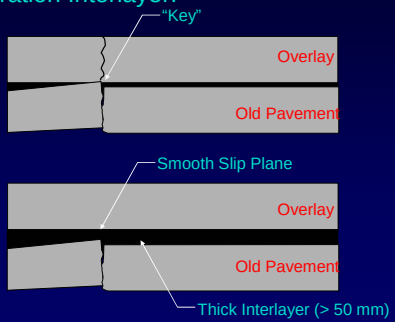
Unbonded Overlays

Separation Interlayer:

- Allows layers to act independently.
- Prevents distresses from reflecting into overlay.
- Typical Interlayer:
  - 1-1 ½ “ Asphalt layer

Unbonded Overlays

Separation Interlayer:



UNBONDED CONCRETE OVERLAYS

Advantages

- Can Place on Pavement in Bad Condition.
- Less Pre-Overlay Repair Needed Than Other Overlay Designs.
- No Future Reflective Cracking.
- Avoid Reconstruction Problems.
- Maintain Traffic.

UNBONDED CONCRETE OVERLAYS

Job-Site Considerations

- **Overhead Structures.**
- **On-line Bridges.**
- **Shoulders.**
- **Fill for Slope Flattening.**
- **Traffic Control.**

UNBONDED CONCRETE OVERLAYS

Payment

Cubic Yard **Square Yard**

NOTE: Divided payment is the most equitable and economic.

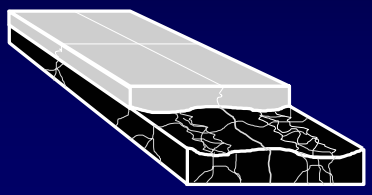
Unbonded Overlays

Performance

- Very Good
- Can be expected to perform for 20+ years.
  - Most failures are due to the use of inadequate separation layers.

Conventional Whitetopping

- Consists of thick concrete layer (100 mm or greater) on top of an existing asphalt pavement.
- Behaves as a new pavement on a strong base.



Whitetopping Engineering Bulletin

- New for 1998
  - Conventional Whitetopping
    - Design
    - Construction
    - Performance
  - Ultra-thin Whitetopping
    - Design
    - Construction
    - Performance

Whitetopping - History

- First Whitetopping
  - South 7th street in Terre Haute, Indiana - 1918
  - 4" concrete overlay of existing asphalt pavement
- During 40's & 50's used to upgrade military & civilian airports
- Highway use started approx. 1960
  - Types have included JPCP, JRCP, CRCP, FRC

Whitetopping History

•Modern usage began in Iowa in 1960's where heavy loads from farm trucks created a need for a durable pavement.

•Performance was excellent

•Over 500 miles of whitetopped roads since the 1960's

•Now used for Interstates, highways, airports, and parking lots

Typical Whitetopping Thickness

- Depends on expected traffic load.
  - City streets, county roads, and small airports
    - 100 to 175 mm (4 to 7 in.)
  - Primary roads and interstate highways
    - 175 to 280 mm (7 to 11 in.)
  - Large airports
    - 200 to 460 mm (8 to 18 in.)

Whitetopping - Advantages

Construction

- Can place on pavement in bad condition.
  - Little or no pre-overlay repair needed.
- Avoid reconstruction problems.
  - Minimal rain delays.
  - Maintain traffic on existing surface.

Whitetopping - Advantages

- Improved structural capacity.
- Maintains high level of serviceability.
- Low maintenance.
- No seasonal weakening (spring breakup).
- Concrete slabs bridge problems asphalt cannot.
- Light reflective, safe riding surface.

Whitetopping - Advantages

Long-term

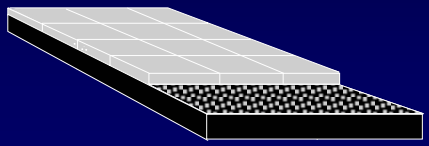
- Low maintenance.
- No seasonal weakening (spring breakup).
- No reflective cracking.
- Safe riding surface.

Whitetopping Construction

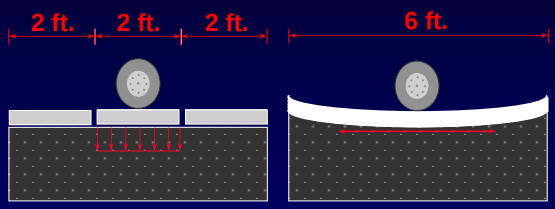
- Critical issue is uniform support
- Subgrade / base failures need repair
- Need to evaluate drainage (esp. Inlays)
- Address surface distortions
  - Direct application
  - Profile milling
  - Leveling course

Ultra-Thin Whitetopping

- Consists of thin concrete layer (4 in. or less) on top of an existing asphalt pavement.
- Specific steps are taken to bond the new concrete to the existing asphalt and to saw short joint spacing.

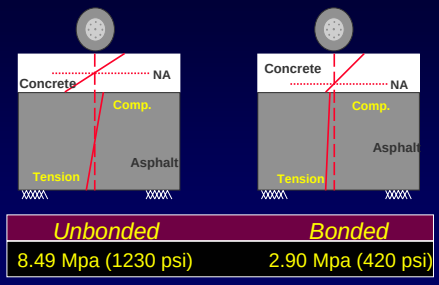


Ultra-Thin Whitetopping



Short joint spacing allows the slabs to deflect instead of bend. This reduces slab stresses to reasonable values.

Bonding Effects on Edge Stress



Unbonded	*Bonded*
8.49 Mpa (1230 psi)	2.90 Mpa (420 psi)

75 mm Concrete, 100 mm AC, K=81 Mpa/m, Ec = 27,580 Mpa, Eac = 2,758 MPa

Known Design Considerations

- Bond is critical.
- Slab size (Jointing) is important.
- Underlying asphalt thickness is important.

OVERLAY PERFORMANCE in INDIANA

Specific Concrete Overlay Projects

Indiana Overlays

• I – 69 North of SR 18 – 11”	1986
• I – 65 North of SR 114 – 10.5”	1994
• 1 – 94 West of SR 39 – 13”	1998
• I – 70 at US 27 – Richmond – 12”	2000
• Harding Street – Indianapolis – 6”	1985
• 121st Street – Fishers – 9”	1992
• Indianapolis Bus Lanes – 3.5”	1997
• Allisonville Rd – N. of 96th – 7”	1999
• 56th Street – Brownsburg – 5”	2001
• Market & Columbia – Warsaw – 3.5”	2002

I-69 UNBONDED PCC OVERLAY

FROM SR 18 RM 66.29

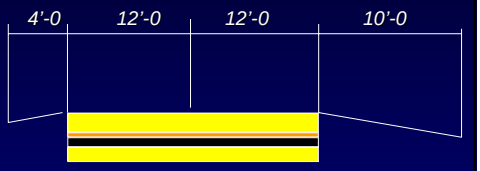
to

GRANT COUNTY LINE RM 71.64

I-69 UNBONDED PCC OVERLAY

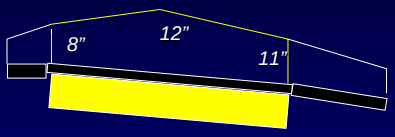
- OPENED TO TRAFFIC 1964
- RESURFACED (Bituminous) 1975
- NBL RESURFACED (Bituminous) 1978
- UNBONDED OVERLAY 1986

I-69 UNBONDED PCC OVERLAY



I-69 UNBONDED PCC OVERLAY

I-65 UNBONDED PCC OVERLAY



Harding Street - Indianapolis

- Old concrete street with patches
- PCC Unbonded overlay placed 1985
- 6" thick over old street
- Widened 6' with 8" PCCP
- Skewed non-doweled transverse joints
- Tied longitudinal joint provided at section thickness change
- Still in excellent condition

Harding Street - Indianapolis

Harding Street - Indianapolis

Harding Street - Indianapolis

Harding Street - Indianapolis

121st Street - Fishers

Allisonville Road

96th Street to Eller Road

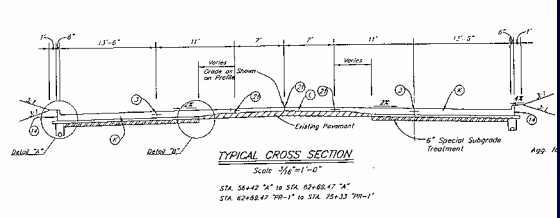
Project Information

- Traffic: 26,360 vpd
- Existing 24’ asphalt pavement
- Scope:
  - widen to outside
  - maintain traffic
  - mill & overlay existing

Pavement Design

- PCCP
  - plain, non-doweled with skewed joints
  - overlay: 7 1/2 “ PCC
  - widening: 10 1/2” PCC on 4” #53 aggregate base
  - Lime treated subgrade
- HMA
  - overlay: 5” HMA
  - widening: 15” HMA
  - Lime treated subgrade

Allisonville Road Cross Section



Allisonville Road

56th Street - Brownsburg

- Commercial and Residential traffic
- 44’ wide, 3500’ long
- 6” concrete overlay with variable depth to 9” as needed
- Center line realignment
- Drainage
- Texture: Turf Drag and Random Tining

56th Street Brownsburg

56th Street Brownsburg

City of Indianapolis

Ultra – thin Whitetopping

Bus Lanes

PLACING CONCRETE

PERFORMANCE

- All three sections are performing well

Market & Columbia Streets - Warsaw

Market & Columbia Streets - Warsaw

Market & Columbia Streets - Warsaw

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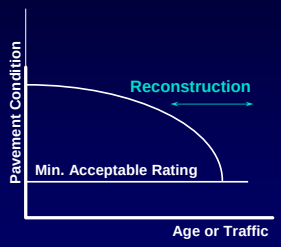
Market & Columbia Streets - Warsaw

Market & Columbia Streets - Warsaw

Madison, IN Airport Apron

Reconstruction

- Used when the pavement has high levels of distress.
- Used after overlays are no longer effective.



Reconstruction Activities

- Final stage of rehabilitation.
- Involves removing and replacing existing pavement with a new pavement.
  - Complete removal & replacement
  - Partial removal & replacement (Inlay).
- Can correct:
  - Subgrade / subbase deficiencies, Roadway geometrics, Roadside safety features, Drainage

Reconstruction Activities

- Controls the final elevation
  - Minimizes roadside appurtenances adjustments.
- Can recycle the old pavement

Summary

- CPR^3 repairs structural / functional deficiencies.
- Improves pavement condition to an acceptable level.
- Appropriate activity depends on the existing pavement condition.
  - As condition declines, the optimum activity changes.
  - Applying correct activity at correct time is essential.

Summary

- Restoration
  - Repairs isolated areas of deterioration.
- Resurfacing
  - Repairs a pavement with medium to high severity levels of distress.
- Reconstruction
  - Used at the end of the pavement's life, when it has very high severity levels of distress.

YOU HAVE OPTIONS.

Questions?